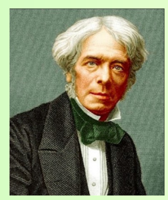
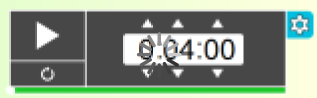
Capacitors	**Capacitors 1 - structure, use and energy**

Learning objectives	**MUST (C)**	Describe the structure of a basic capacitor and how it charges
	SHOULD (B)	Understand the unit of capacitance and how to calculate capacitance for a capacitor
	COULD (A/A*)	Calculate the energy stored in a capacitor

STARTER: Why does a touch lamp switch on when you touch it?



EXTENSION: What's the odd one out?



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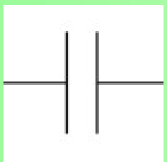
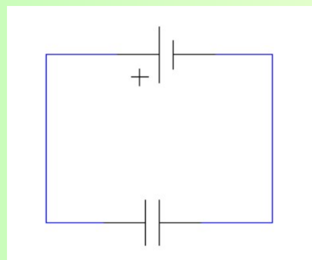
MUST (C)	Describe the structure of a basic capacitor and how it charges

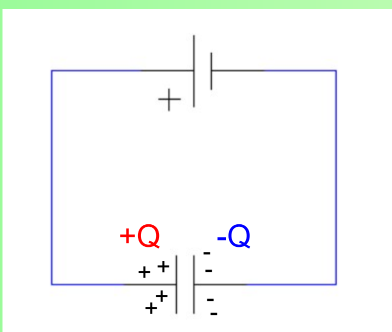


This component is a **capacitor**; it's two metal plates separated by a vacuum, air, or an insulator, which is known as a **dielectric.**

What will happen when a capacitor is connected to a cell, or other power source?

Extension: When will it stop happening?





When the capacitor is first connected to the power supply, electrons flow to one plate and away from the other plate.

This stops when the potential difference across the plates = emf of the power supply. At this point, the capacitor is fully charged; the plates have charges +Q and -Q. A capacitor is a device for **storing charge**.

When we use capacitors, we can store charge and then discharge this charge very quickly. This ability to release charge is useful in many applications, including:

- Camera flashes
- Lasers
- Back-up power supplies

Capacitance	**Capacitors 1 - structure, use and energy**
SHOULD (B)	Understand the unit of capacitance and how to calculate capacitance for a capacitor

Capacitance (C) is the amount of charge stored per unit of potential difference.

$$C = \frac{Q}{V}$$

Unit of capacitance: Farad

1 F = 1 C/V

1F is very large; commonly use pF, nF or μF

(a) A capacitor of capacitance 5 μF is connected to a 6 V supply. What charge is stored in the capacitor?
(b) A 400 pF capacitor carries a charge of 2.5×10^{-8} C. What is the potential difference across the plates of the capacitor?

Extension: When a capacitor is charging, what would a charge/time graph look like? Would it be a straight line? Justify your answer.

(a) $Q = CV = 5 \times 10^{-6} \times 6 = 30 \times 10^{-6} = 30\ \mu C$
(b) $V = Q/C = 2.5 \times 10^{-8} / 400 \times 10^{-12} = 62.5\ V$

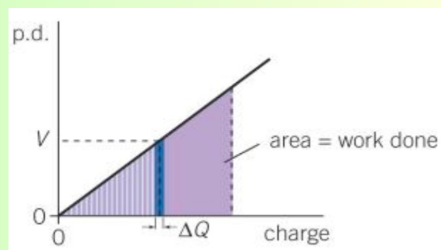
Capacitors	**Capacitors 1 - structure, use and energy**
COULD (A/A*)	Calculate the energy stored in a capacitor

During the process of charging a capacitor, electrons are added to one plate (which becomes increasingly negative) and removed from another plate (which becomes increasingly positive).

Electrons are repelled by negative charges, and attracted by positive ones. Therefore, to add them to a negative plate or remove them from a positive one requires **work** to be done. Because work is done on the electrons, energy is stored in the capacitor.

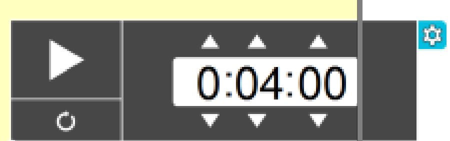
E = QV, so for a change of ΔQ the extra energy stored would be ΔQV.

As Q changes, V changes; but the total work done will always be the area under the graph.



The Q-V graph for a capacitor is a straight line; the area underneath it, which is the energy stored, is $\frac{1}{2}QV$

Can you use C = Q/V to derive two other expressions for energy stored?



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PLENARY:

A nuclear fusion device is required to deliver at least 1 MJ of energy using capacitors. If the largest workable potential difference is 10 kV, what is the minimum capacitance of the capacitors that should be used?

A 0.01 F

B 0.02 F

C 2 F

D 100 F

B

(Total 1 mark)

https://www.youtube.com/watch?v=KDG15-iTJLw

0:04:00

May 5-23:40